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TWO NON-INVASIVE TECHNIQUES FOR THE STUDY OF THE SURFACE OF CULTURAL HERITAGE OBJECTS: OPTICAL MEASUREMENT OF MICRO-ROUGHNESS AND BACKSCATTERING SPECTRO-COLORIMETRY

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ABSTRACT

Non invasive measurements with portable devices are becoming the general trend for the development of instruments dedicated to the study of heritage objects.

Two instruments are described in this paper, based on two distinct surface features that are colour and texture, using particular set-ups adapted to our needs: a spectro colorimeter operating in backscattering mode and a roughness-meter using a field extension obtained by stretching the axial chromatism dioptric. Examples of application illustrate their use.

INTRODUCTION

Within the large set of techniques of examination and analysis available at the C2RMF, growing interest is put on non-invasive techniques and particularly to those implemented on portable instruments. Conventional measurement of colour and texture can be the basis of such tools.

THE GONIO-SPECTROCOLOR METER

An instrument dedicated to colour measurement, notably on varnished paintings, was developed at the C2RMF, a dozen years ago, at the initiative of Michel Menu, with the help of Alain Chiron and Françoise Viénnot from the Photobiology Laboratory of the MNHN[1]. One of the objectives was to reduce the influence of specular scattering due to the protective varnish. The solution of this problem relies on the use of backscattering mode. The principle is to use for colour measurement the fraction of scattered light which follows the same path as the incident light. For practical reasons, we use an angle of 22° in our set-up. Since the first tests, much progress has been made and today, on the basis of our results, this backscattering geometry and other functionalities are offered on commercial instruments such as those from STIL. Examples chosen to illustrate this technique were accomplished with the last prototype.

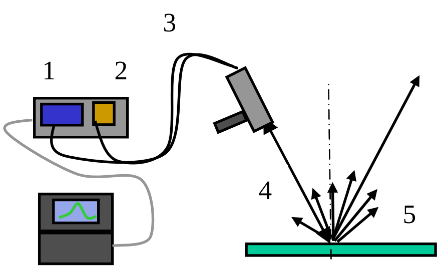

Figure 1. The spectro-color meter principle : 1 spectrometer, 2 halogen lamp, 3 optic fibres, 4 the same way for incidence and reflectance rays, 5 sample.

Examples

Example 1. Research on the "Prussian blue" pigment in the works of painters Watteau and his contemporaries.

Prior to the synthesis of “Prussian blue” painters used mainly indigo and lapis lazuli. The study conducted by Myriam Eveno (C2RMF) consisted in spectro-colorimetric measurements in order to identify the different blue pigments used in paintings from the Louvre museum collection. Measurements were made either directly in the museum rooms or in the C2RMF laboratory.

Figure 2. Colour measurement on site

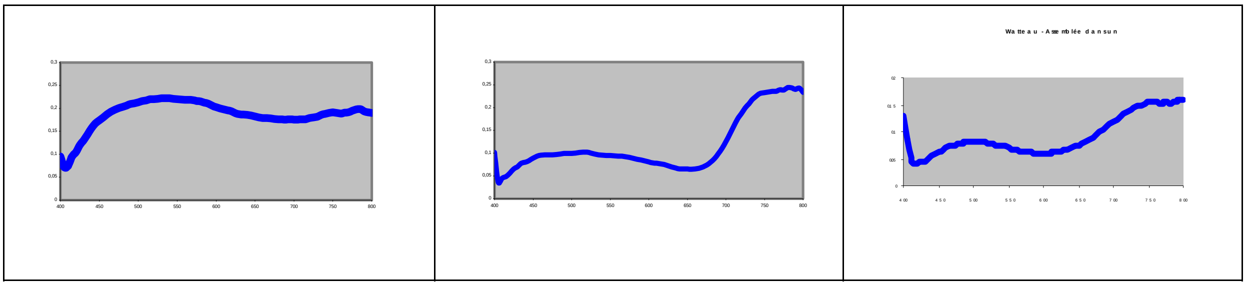

Figure 3. Prussian blue, indigo and lapis lazuli spectrum

Example 2. Influence of varnish on the dynamics of visual appearance of the back of violin made of the wood of waved maple.

To increase our knowledge on this wood we performed a colorimetric study to measure the colour difference ΔE between clear waves and dark waves, without and with varnish. The varnish enhances the colour difference by a factor of ten.

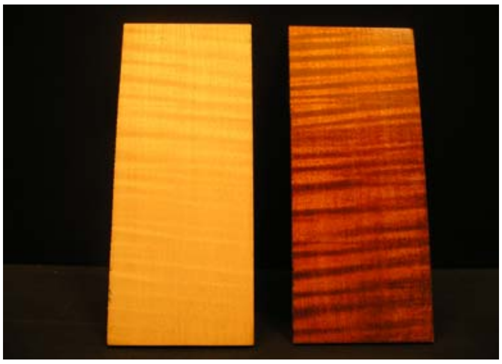

Figure 4. Waved Maple samples without and with varnished

	L*	a*	b*	ΔE76
Clear wave maple no varnish	88,23	4,82	20,80	
Dark wave maple no varnish	86,22	5,47	22,56	2,8
Clear wave maple varnish	62,42	20,91	71,52	
Dark wave maple varnish	30,66	23,87	41,45	43,9

Figure 5. Colour difference between clear waves and dark waves, without and with varnished

THE OPTICAL ROUGHNESS-METER

The new optical roughness-meter is based on a quasi confocal, z-axis extended field. This axis field extension is obtained by stretching the axial chromatism generally encountered in a classical confocal dioptric setup when working with a polychromatic point source. One can then get a continuum of monochromatic diffraction limited images corresponding to the extent of the spectral composition of the light source. It then appears that the very specific optical sectioning property of the classical monochromatic confocal setup - which basically can be considered as being a "single point" viewing system - is perfectly preserved for each wavelength and consequently the chromatic confocal setup turns to be a "single (axial) segment" viewing system with a univocal colour coding (figure 6).

A table of translation in x allows to perform a linescan and thus to acquire a contour. A second table of translation permits to transform a suite of lines into a surface (figure 7) and thus to obtain a micro-topographic image of the surface to analyse.

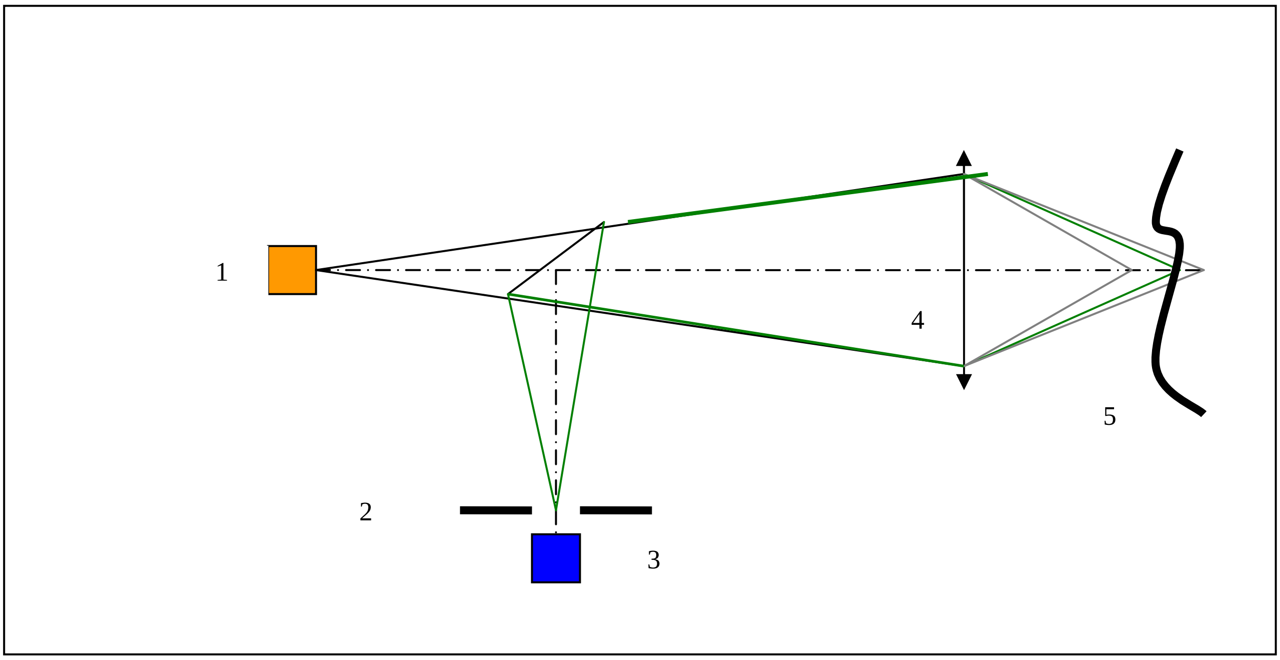

Figure 6.. The optic confocal roughness meter principle:
1 halogen lamp, 2 spatial filter, 3 spectrometer, 4 axial chromatic lens, 5 surface object.

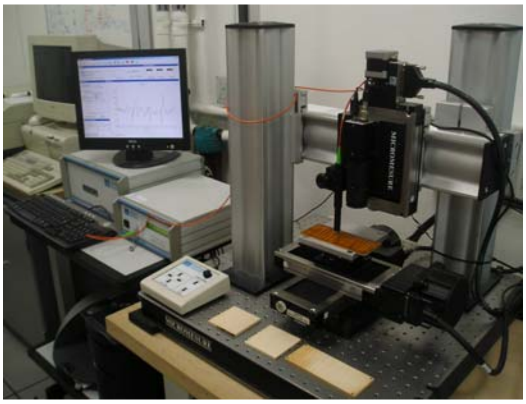

Figure 7. The confocal sensor and the table of translation in x,y.

Examples

Example 1. Measurement of the thickness of a varnish layer and surface roughness

Generally the thickness of a varnish layer is about 50µm. For this thickness value, the choice of a sensor of short field is obvious. We choose a sensor with a field of 200µm and measurement is made every 100µm on a length of 12mm. The results confirm expectation, the medium value being close to 50µm (figure 7).

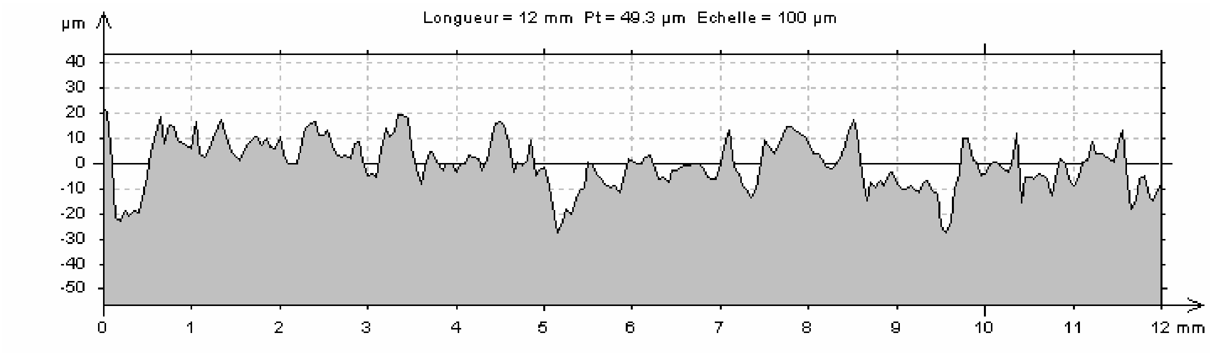

Figure 8. Result of the thickness of a varnish.

On the same distance, step by step, we acquire at the same time the roughness of the varnished surface and the roughness of wood under varnish.

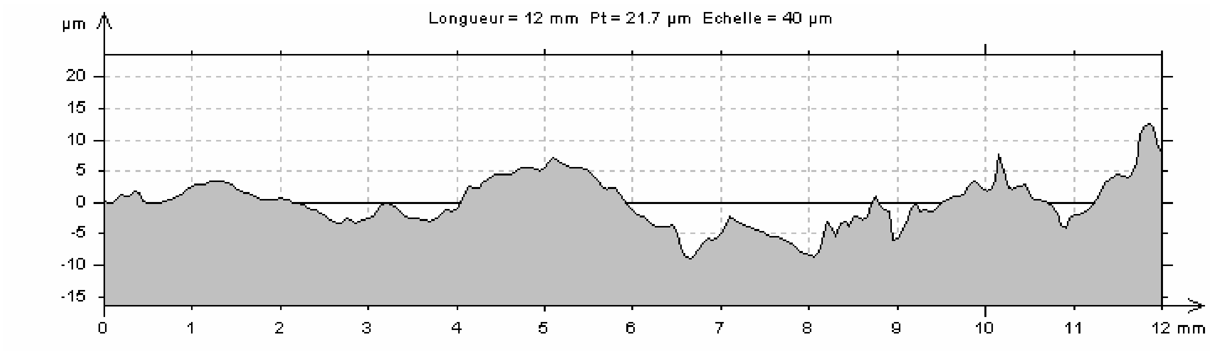

Figure. 9. Roughness in the varnished surface: Ra = 0,38 µm

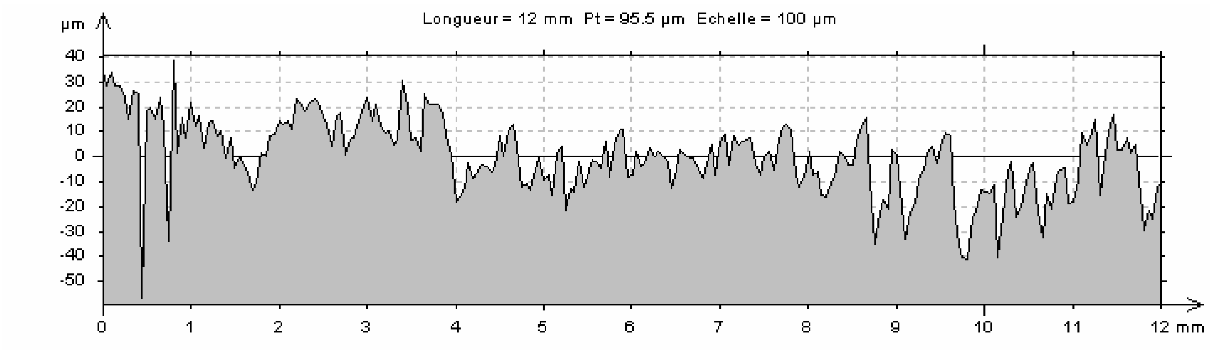

Fig. 10. Roughness of wood under the coat of varnish: Ra = 4,5 µm

Example 2. Study conducted by Dominique Robcis, conservator (C2RMF) on the technique for manufacturing a silver buckle (diameter of 25,8mm) decorated with niello, from the 14th century.

Niello is a black alloy used for the decoration of silver pieces. This engraved buckle is inlaid with niello on both faces, contrary to conventional practice which uses different alloys on these faces for temperature constraint. The morphological examination of the niello used in this object, carried out with the micro-topographic station reveals a marked difference between the two faces which likely results from different heating times.

Figure 11, 11a.. The buckle photography.

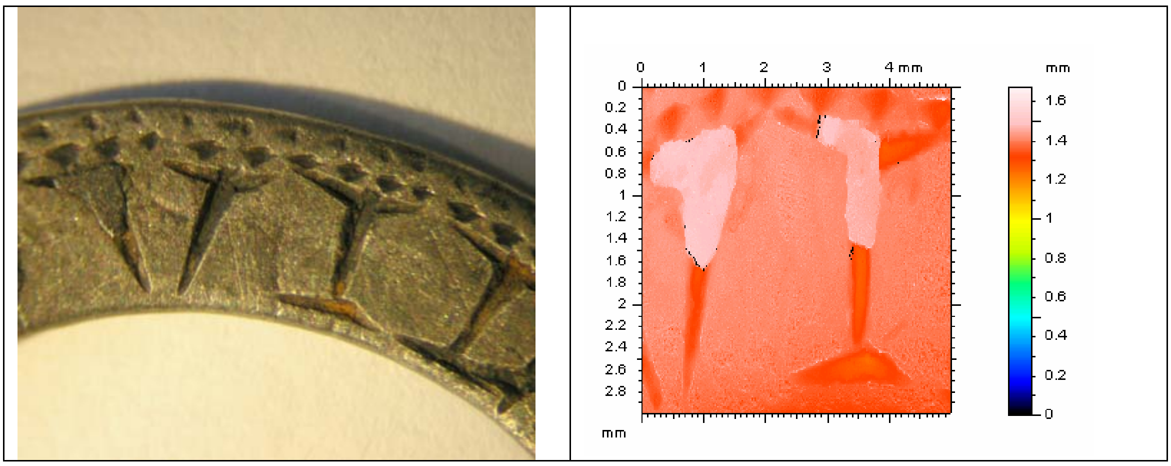

Figure 12. blow up and false colours

Example 3. The study of the polish of sculpture from Desiderio da Settignano, artist of XV ° century [2].

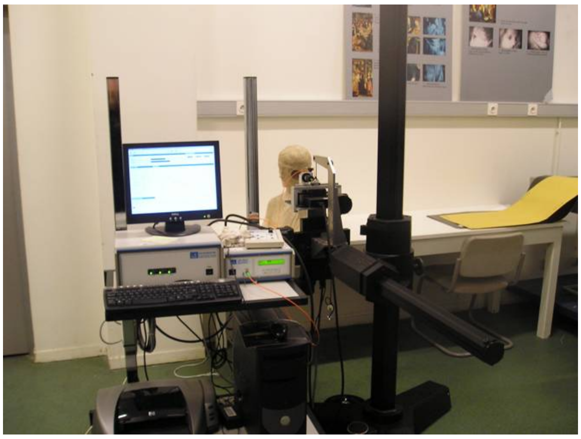

Figure 13. the transportable installation

The measurements performed permit to notice a small difference of polish between different parts of the sculpture. For instance, the mean roughness of a naked part is Ra = 1,23µm and that of the cloth Ra = 2,43µm, while it is three times larger in the hair zone. However it is not clear whether such a difference is the signature of the artist's technique or is due to weathering.

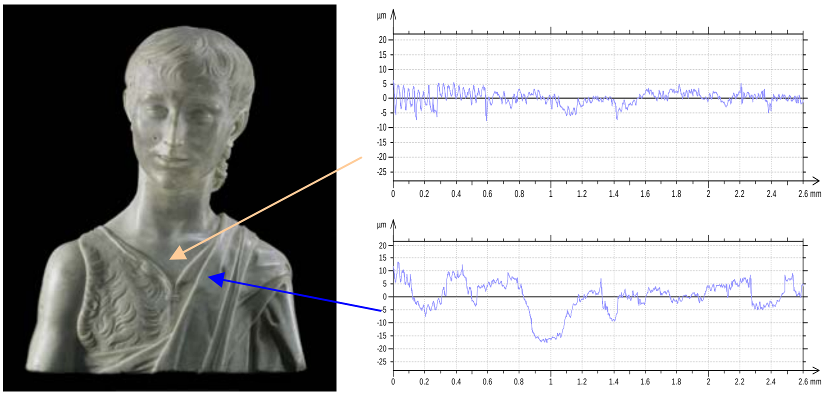

Figure 14. Saint Jean-Batiste measurement(Louvre)

This analytical technique should permit to differentiate the work of Desidério da Settignano from several contemporary artists on the basis of the quality of polish.

CONCLUSION

It is obvious that this kind of investigation can only be carried out in an interdisciplinary context where art historian, conservation scientist, conservator and photographer share their knowledge and their skill.

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